

## FACTORS INFLUENCING FISH ASSEMBLAGES OF A HIGH-ELEVATION DESERT STREAM SYSTEM IN WYOMING

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**ABSTRACT.**—Seven fish species were found in the Bitter Creek drainage of southwest Wyoming, but only speckled dace (*Rhinichthys osculus*), flannelmouth sucker (*Catostomus latipinnis*), and mountain sucker (*Catostomus platyrhynchus*) were indigenous. No relationships were found between fish standing stocks and habitat features, but species richness was related to elevation and stream width. No fish were found above an elevation of 2192 m. Only the most downstream study reach had more than three species present. Two indigenous species, speckled dace and mountain sucker, and a nonnative species, fathead minnow (*Pimephales promelas*), were predominant fishes in the drainage. These three species withstand intermittent stream flows that are common in the drainage.

*Key words:* fish, streams, desert, Wyoming, habitat, distribution.

Fish communities in streams become more complex as habitat diversity increases along the length of a stream. Variation in fish community structure within a stream system can follow patterns of zonation or addition. Specific fish communities can be associated with zones defined by water temperature or geomorphologic features, or community complexity can increase with progression downstream by addition of species (Moyle and Nichols 1973, Guillory 1982, McNeely 1986, Hughes and Gammon 1987, Platania 1991, Rahel and Hubert 1991). However, such patterns may differ in arid drainages of the western United States with depauperate ichthyofauna (Cross 1985).

Little is known about the fish communities in high-desert stream systems in southwestern Wyoming. Annual precipitation over most of these drainages is <16 cm, with much of it as snow in headwater areas during late winter and thunderstorms during late summer. Discharge is highest during spring runoff, and streams frequently become intermittent during summer and winter. Because these systems in Wyoming are at high elevations (>1800 m above mean sea level), water temperatures are cool compared with other desert streams. The climate in these areas typically consists of dry, moderately warm summers with long, cold winters.

The purpose of this study was to (1) describe fish species present in a high-desert stream

system in southwestern Wyoming and (2) determine the factors that influence fish abundance and community structure within the drainage.

### STUDY AREA

The study was conducted in an intermittent drainage, Bitter Creek, a tributary to the Green River in the Red Desert of southwest Wyoming (Fig. 1). The study area consists of Bitter Creek and four tributaries—Little Bitter, Salt Wells, Bean Springs, and Gap creeks. Frequently, no measurable surface flow occurs in Bitter Creek at Bitter Creek, WY, during midsummer and midwinter (flow data available in the Water Resources Data System at the Wyoming Water Resources Center, University of Wyoming, Laramie). Bitter Creek at Salt Wells, WY, generally has no measurable surface flow from July to February. Salt Wells Creek has more persistent flows near its mouth, but records of no measurable flows occur in midsummer and midwinter. When no measurable flow occurs in these streams, isolated pools of standing water can be found in the stream channels. Elevation of the study area ranges from 1800 to 2400 m.

Streams in the Bitter Creek drainage typically are downcut by at least 1.5 m, with steep clay banks having no vegetation. Riparian vegetation consists of grasses and sagebrush (*Artemisia* spp.); upland vegetation is primarily the latter.

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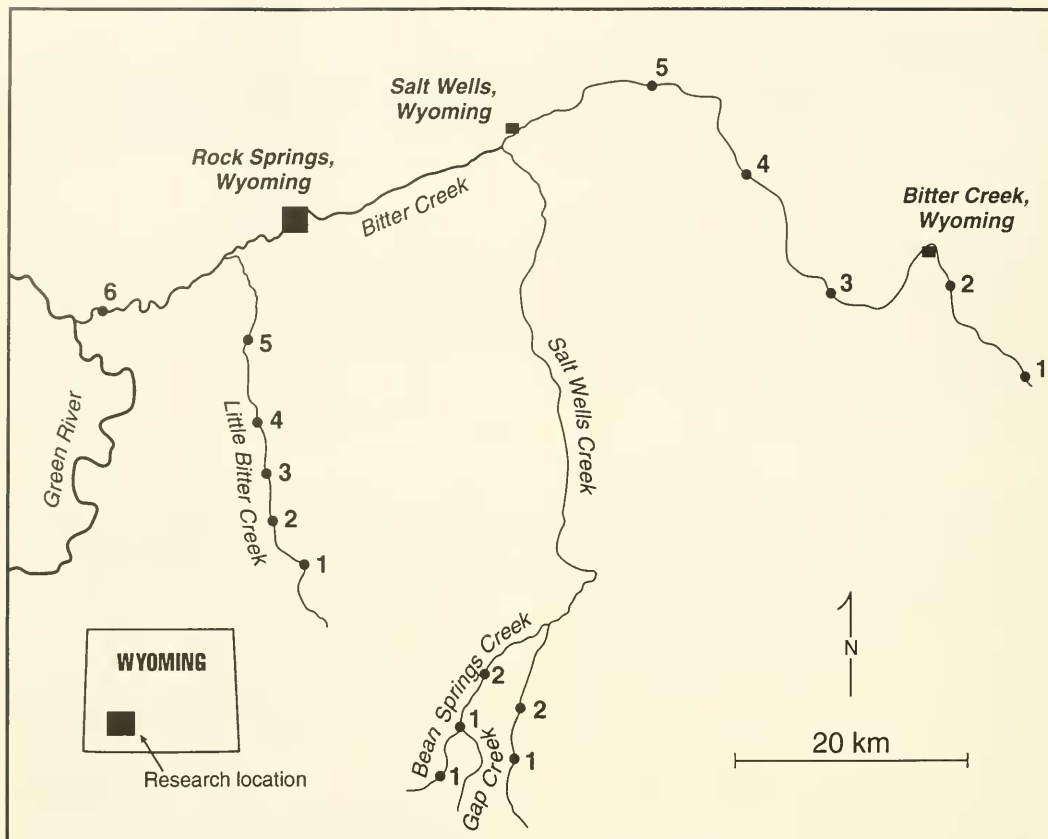


Fig. 1. Map of the Bitter Creek drainage, WY, showing the location of the 16 study reaches.

Baxter and Simon (1970) reported four fish species in collections at two sites in Bitter Creek. Speckled dace (*Rhinichthys osculus*), fathead minnow (*Pimephales promelas*), and mountain sucker (*Catostomus platyrhynchus*) were reported from a site about 10 km upstream from the mouth. Bluehead sucker (*Catostomus discobolus*) was the only species reported from a site near Salt Wells.

#### METHODS

Sixteen 100-m-long study reaches were selected to represent variation in stream size and habitat in the drainage during summer 1993. Wetted width, mean depth, and substrate were determined across transects at 10-m intervals. Dominant substrate at each transect was visually determined following Bain et al. (1985): sand-silt (<2 mm diameter), gravel (2–16 mm), pebble (17–64 mm), cobble (65–256 mm), and boulder (>256 mm). Water

velocity was determined within each reach using the dye flow method (Binns 1982). Stream discharge at time of sampling was computed from width, depth, and velocity.

Alkalinity, hardness, and pH were measured at the time of sampling. Alkalinity and hardness were determined with field test kits (Hach Model A1-36DT), pH with an electronic meter. Mean elevation and channel slope at each study reach were estimated from 7.5-minute topographic maps.

Fish were sampled in each 100-m reach by electrofishing. Small-mesh (6.4-mm) block nets were placed at each end, and two or three electrofishing passes were made over the entire reach. Three-pass depletion estimates of species abundance were made in most reaches. Two-pass depletion estimates were used when >80% of fish captured by the first two passes were captured during the first pass. Fish abundance was computed using the Zippin method (Platts et al. 1983). All fish were

weighed to enable computation of standing stock estimates.

Standing stocks of individual species, total standing stock of all species, and number of species in a reach were evaluated for their relation to nine habitat variables using simple-linear and multiple-regression analyses. Independent variables were included in regression models if they were significant at  $P \leq .05$ . We further limited inclusion of dependent variables in multiple-regression models to ones that were not correlated at  $P \leq .05$ . Computations were performed using Statistix 4.0 (Analytical Software 1992).

## RESULTS

Seven fish species were collected: speckled dace, fathead minnow, Utah chub (*Gila atraria*), Bonneville redbreast shiner (*Richardsonius balteatus hydrophlox*), mountain sucker, white sucker (*Catostomus commersoni*), and flannel-mouth sucker (*C. latipinnis*). Abundance varied substantially among study reaches (Table 1). Mean total standing stock of all species was  $3.0 \text{ g/m}^3$  and ranged from 0 to  $21.3 \text{ g/m}^3$ . No fish were found in the four reaches above 2192 m.

Habitat features varied among the 16 study reaches (Table 2). Flow was measurable at all reaches. Stream width, water velocity, and discharge increased downstream. Sand-silt substrate occurred over >90% of almost all study reaches. Alkalinity, pH, and hardness also increased downstream.

No significant relations were found between any of the nine habitat variables and standing stocks of individual species or total standing stock of all species. However, there were significant relations between the number of species and four habitat variables:

$$\begin{aligned} \text{NS} &= 20.85 - 0.0091 \text{ E} \quad (P = .0003, R^2 = .61), \\ \text{NS} &= 0.13 + 0.512 \text{ W} \quad (P = .0010, R^2 = .52), \\ \text{NS} &= 3.40 - 11.008 \text{ V} \quad (P = .029, R^2 = .33), \text{ and} \\ \text{NS} &= 0.57 + 31.245 \text{ F} \quad (P = .022, R^2 = .32), \end{aligned}$$

where NS = number of species, E = elevation in meters, W = mean wetted width in meters, V = water velocity in meters per second, and F = flow in cubic meters per second. The best two-variable model was

$$\text{NS} = 14.36 - 0.0065 \text{ E} + 0.53 \text{ W} \quad (P < .0001, R^2 = .50).$$

As study reaches declined in elevation and as width, water velocity, and discharge increased, the number of species increased.

Because the most downstream reach on Bitter Creek had twice as many species as any other reach and flow at the reach was enhanced by discharge from a sewage treatment plant, we assessed relations with the omission of that reach. Again, no relationships were found between any of the habitat variables and standing stocks of fish, but the number of species (NS) was significantly related to elevation (E) and water velocity (V):

$$\begin{aligned} \text{NS} &= 15.95 - 0.0068 \text{ E} \quad (P = .0014, R^2 = .55), \text{ and} \\ \text{NS} &= 3.00 - 10.11 \text{ V} \quad (P = .0018, R^2 = .51). \end{aligned}$$

Among the 15 study reaches with a maximum of three species present, the number of species increased with decline in elevation and water velocity.

## DISCUSSION

Of the seven fish species in the Bitter Creek drainage, only three—speckled dace, flannel-mouth sucker, and mountain sucker—are indigenous (Baxter and Simon 1970). Absence of fish above 2192 m is probably due to a climate that is too cold for warmwater fishes. Additionally, no trout occur naturally or have become naturalized in the watershed.

The number of species increased with progression from headwater to downstream reaches (Table 1). With the exception of the most downstream reach on Bitter Creek, no more than three species—speckled dace, mountain sucker, and fathead minnow—were found in any of the study reaches. The high-elevation reaches with fish tended to have predominantly or exclusively speckled dace and mountain sucker.

Much of the increase in species richness with downstream progression was due to the most downstream reach on Bitter Creek where six species were found (Table 1). Four of six species were not natives—fathead minnow, white sucker, Utah chub, and Bonneville redbreast shiner. Mountain sucker was not found in this reach, but it was common throughout most of the Bitter Creek drainage. While this study reach was lowest in elevation among the 16 study reaches, it also was downstream from the outfall of the wastewater treatment facility

TABLE 1. Standing stocks (g per m<sup>2</sup>) of fishes at 16 study reaches in the Bitter Creek drainage, WY, sampled during summer 1993.

Species	Bitter Creek						Little Bitter Creek					Salt Wells Creek	Beams Spring	Gap Creek		
	1	2	3	4	5	6	1	2	3	4	5	1	2	1	2	
Speckled dace	2.5	1.1	0.8	<0.1	0.5	<0.1			0.2	0.4	0.4				5.7	0.2
Mountain sucker	1.7	<0.1	2.3		0.4				5.8	1.8	0.2				15.6	
Fathead minnow								2.9	0.5	0.4						0.5
Flannelmouth sucker						2.4										
White sucker						2.2										
Utah chub						<0.1										
Bonneville redbside shiner						<0.1										
Total	4.2	1.2	3.1	<0.1	1.0	4.7			6.5	2.6	0.6				21.3	0.7

TABLE 2. Habitat features at 16 study reaches in the Bitter Creek drainage, WY, sampled during summer 1993.

Habitat feature	Bitter Creek						Little Bitter Creek					Salt Wells Creek	Beams Spring	Gap Creek		
	1	2	3	4	5	6	1	2	3	4	5	1	2	1	2	
Mean wetted width (m)	1.3	1.9	2.7	1.2	1.8	7.2	2.0	1.4	2.4	2.1	1.3	1.2	2.1	0.8	1.3	1.3
Mean water depth (m)	0.14	0.13	0.26	0.21	0.15	0.14	0.08	0.09	0.20	0.09	0.18	0.13	0.09	0.12	0.12	0.21
Water velocity (m/second)	0.10	0.16	0.09	0.07	0.06	0.13	0.13	0.27	0.12	0.13	0.05	0.32	0.27	0.25	0.14	0.11
Discharge (m <sup>3</sup> /second)	0.02	0.04	0.06	0.02	0.01	0.13	0.02	0.03	0.06	0.02	0.01	0.05	0.05	0.02	0.02	0.03
Channel slope (%)	0.2	0.3	0.1	0.2	0.1	0.1	2.1	1.1	0.8	0.7	0.4	2.8	2.8	1.4	2.1	0.5
Elevation (m × 1000)	2.10	2.06	2.02	2.00	1.98	1.88	2.33	2.12	2.06	2.04	1.96	2.38	2.29	2.29	2.18	2.09
Alkalinity (mg/L × 100)	2.6	2.8	2.6	2.5	2.7	3.8	2.0	3.0	2.6	2.9	3.3	2.4	3.8	2.2	2.2	2.2
Hardness (mg/L × 100)	1.9	1.7	2.0	2.1	3.2	9.5	2.6	5.2	4.6	4.8	14.5	2.8	7.6	3.4	3.5	4.6
pH	6.6	9.3	7.9	8.0	7.2	8.7	7.0	7.6	8.1	8.5	7.7	8.5	7.9	8.0	7.8	9.5

for Rock Springs, WY, and was only 13 km upstream from the confluence of Bitter Creek and the Green River. The more permanent flows due to the wastewater treatment facility may have enabled fish not adapted to intermittent flows to persist in this reach. Also, the relatively short distance to the Green River may enable upstream migration of fish to this reach, contributing to higher species diversity. Repeated invasion of nonnative species from downstream reservoirs maintains species diversity in the Virgin River, UT (Cross 1985). Also, human disturbances have been found to create environmental conditions favorable to nonnative fish in California (Moyle and Nichols 1973, 1974). Therefore, enhanced flows due to the wastewater treatment facility and invasion of nonnative species from the Green River probably contribute to the diversity of fish in the downstream portion of Bitter Creek.

During summer 1993, flowing water occurred at all study reaches when they were sampled. Precipitation in spring and summer 1993 was substantially greater than normal, enabling measurable surface flows to persist during summer. However, study reaches upstream from the outfall of the Rock Springs, WY, wastewater treatment facility are frequently intermittent during late summer. Fathead minnow has been described previously as a species associated with intermittent streams (Baxter and Simon 1970, Pflieger 1975). Our observations indicate that two indigenous species—speckled dace and mountain sucker—and one introduced species—fathead minnow—can survive in the frequently intermittent streams. Consequently, these three fishes are the only species occurring over most of the Bitter Creek drainage, but fathead minnows tend to be limited to lower elevations than the two native species. It is not known how the invasion by fathead minnow may affect the native speckled dace and mountain sucker in this desert stream system.

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